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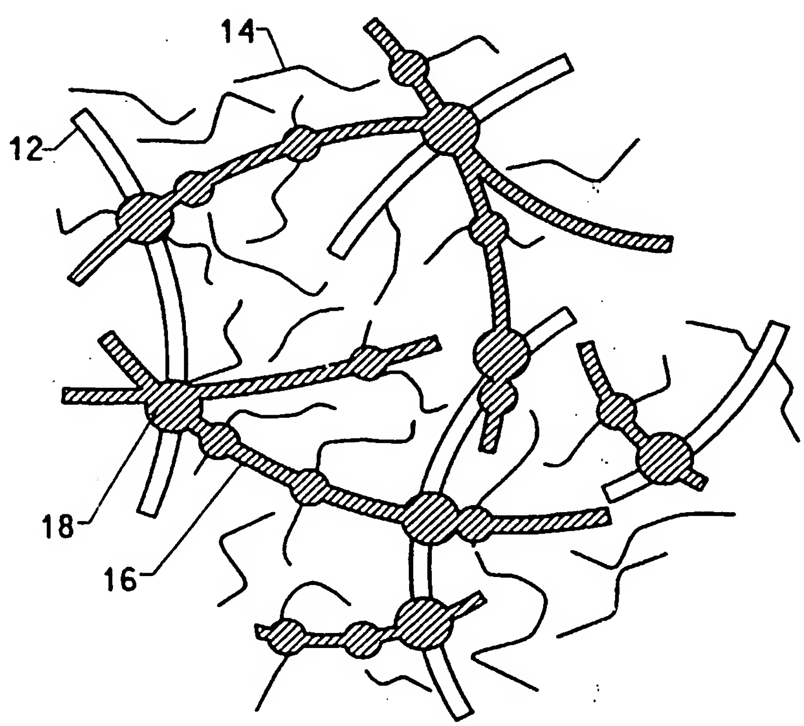
(54) Title: NONWOVEN FABRIC AND METHOD OF MANUFACTURE





**(57) Abstract:** The invention provides a nonwoven fabric having isotropic recovery from extension of at least about 55 % and comprising a binder, about 3 to 50 weight percent bare elastomeric staple fibers based on weight of the fabric, and crimped staple bicomponent fibers.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# NONWOVEN FABRIC AND METHOD OF MANUFACTURE

## BACKGROUND OF THE INVENTION

### Field of the Invention

The present invention relates to stretch nonwoven fabrics, more particularly such fabrics comprising elastomeric fibers, a binder (especially binder fibers), and crimped fibers.

### Description of Background Art

Nonwoven fabrics have been disclosed that contain elastomeric polyurethane and polyetherester fibers, for example United States Patent US 5238534 and Published Japanese Patent Applications JP 43-026578, JP03-019952, and JP10-025621. However, such fabrics can be unattractively heavy and can have poor, tacky hand. Nonwoven fabrics have also been disclosed that contain crimped fibers, for example United States Patent US5102724 and Published Japanese Patent Applications JP02-091217 and JP05-171555, but they can have poor, and anisotropic, stretch and recovery properties. Both these types of deficiencies can make the nonwovens of the prior art unsatisfactory for direct contact with skin, for example in diapers.

Cross-laid carded webs have been used to make machine- and cross-direction properties similar, for example as disclosed in International Patent Application WO00/63478 and in Published Japanese Patent Applications JP08-260313 and JP11-061617, but such operations add cost, and the fabrics can be thick and can have poor hand, low flexibility, and/or poor stretch and recovery properties.

Laminates of nonwoven webs and elastomeric materials have also been disclosed, for example in Published Japanese Patent Application JP08-188950, but such fabrics, again, can be unevenly thick and of low flexibility so that they do not satisfactorily hug parts of the body.

Nonwovens comprising binder fibers have also been disclosed, for example in United States Patent US5302443 and Published Japanese Patent Application JP2000-328416, but such fabrics typically lack adequate stretch-and-recovery properties.

There is still a need for thin nonwovens having good hand and good stretch-and-recovery properties.

## SUMMARY OF THE INVENTION

The present invention provides a nonwoven fabric having isotropic recovery from extension of at least about 55% and comprising a binder, about 3 to 50 weight percent bare elastomeric staple fibers based on weight of the fabric, and crimped staple bicomponent fibers.

The invention also provides a method of manufacturing such a nonwoven fabric comprising the steps of (a) providing staple spandex, staple latent crimp fibers which develop crimp when heated, and binder fibers; (b) preparing a suspension of the spandex, the latent crimp fibers and the binder fibers; (c) forming the suspension into a web by a process selected from the group consisting of air-laid and wet-laid; (d) heating the web to melt the binder fibers and bond the fibers; and (e) heating the web in a relaxed state to develop crimp in the latent crimp fibers.

## BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is a perspective view (Figure 1A) and a schematic detail (Figure 1B) showing one embodiment of the nonwoven fabric of the invention.

Figure 2 shows enlarged cross-sectional schematic views taken along lines IIA-IIA (Figure 2A) and IIB-IIB (Figure 2B) of Figure 1.
Figure 3 is a schematic view of a nonwoven fabric production apparatus.
Figure 4 schematically shows the web before heating (Figure 4A) and after heating (Figure 4B).

## DETAILED DESCRIPTION OF THE INVENTION

It has now been unexpectedly found that nonwoven fabrics comprising a binder, crimped staple fibers, and bare elastomeric staple fibers have an unusual combination of good hand as indicated by lack of tackiness, good recovery from extension after repeated stretching even at low elastomeric fiber content, and low basis weight and thickness. They are also flexible and have isotropic mechanical properties. The fabrics are well-suited to articles having stretch properties, such as apparel interlinings, diapers, substrates for external medications, wiping cloths, and packaging materials.

As used herein, "elastomeric fiber" means a bare (uncovered) staple fiber which, free of diluents, has a break elongation in excess of 100% independent of any crimp and which when stretched to twice its length, held for one minute, and then released, retracts to less than 1.5 times its original length within one minute of being released. Such fibers include, but are not limited to, rubber fiber, spandex, polyetherester fiber, biconstituent fiber, and elastoester. "Spandex" means a manufactured fiber in which the fiber-forming substance is a long chain synthetic polymer comprised of at least 85% by weight of a segmented polyurethane. "Isotropic mechanical properties" means that properties, such as tensile strength and recovery from extension, in the cross-direction of the fabric are at least 80% of those in the machine-direction of the fabric. "Biconstituent fiber" means a manufactured fiber having one component of a first general class of polymer, for example a thermoplastic elastomer, and a second component of a second general class of polymer, for example a thermoplastic non-elastomer, both components being substantially continuous along the length of the fiber; the fiber can have a concentric or eccentric sheath-core or side-by-side construction. "Bicomponent fiber" means a fiber in which two polymers of the same general class are in a side-by-side or eccentric sheath-core relationship and includes both crimped fibers and fibers with latent crimp that has not yet been realized.

Referring first to Figure 1A, one embodiment of nonwoven stretch fabric 10 of the invention is schematically illustrated. The detail in Figure 1B reveals that the fabric comprises elastomeric fibers 12, crimped fibers 14, and a binder 16 which bonds elastomeric fibers 12 to crimped fibers 14, for example at points of contact 18 therebetween so that the stretch and recovery properties of the elastomeric and the crimped fibers are not impaired.

Referring now to Figures 2A and 2B, cross-sections of one embodiment of the nonwoven stretch fabric of the invention are shown schematically to comprise elastomeric fibers 12, crimped fibers 14, and a binder 16 . Crimped fibers 14 are shown as side-by-side bicomponent fibers comprising components 14x and 14y. Binder 16 is shown as a sheath-core binder fiber comprising sheath 16x and core 16y.

The nonwoven fabric of the invention comprises about 3 to 50 weight percent, preferably about 5 to 30 weight percent, bare elastomeric staple fibers, based on the weight of the fabric. When the amount of

elastomeric fiber is less than about 3 weight percent, the ability of the fabric to recover from extension can be unsatisfactory, and when the amount of elastomeric fibers is more than about 50 weight percent, the elastomeric nonwoven fabric can have an unpleasant, sticky hand.

The fabric preferably further comprises about 40 to 80 weight percent crimped staple fibers, more preferably about 50 to 70 weight percent, based on the weight of the fabric. At an amount less than about 40 weight percent, the nonwoven fabric can have decreased stretch properties, poor flexibility, and a hard hand. At an amount greater than about 80 weight percent, the fabric can have poor mechanical strength and thus a diminished ability to recover from extension when repeatedly stretched.

The fabric preferably also comprises about 10 to 50 weight percent of a binder, more preferably about 20 to 40 weight percent, based on the weight of the fabric. At an amount less than about 10 weight percent, the fabric can have poor mechanical strength, and at more than about 50 weight percent, the stretch properties can be compromised, and the fabric can have an unacceptably hard hand.

The fabric of the invention has a recovery from extension of at least about 55% and can have a thickness of at least about 50 microns and less than 135 microns.

Examples of useful elastomeric fibers include spandex, polyetherester elastomeric fibers, and polyetheramide elastomeric fibers. Natural rubber, synthetic rubber, and semi-synthetic rubber can also be used, as can biconstituent fibers. Spandex is preferred, and spandex comprising polyurethaneurea is more preferred. Polyurethaneureas can typically be prepared from a polymeric glycol, a diisocyanate, and a diamine or alcoholamine chain extender.

The linear density of the staple elastomeric fibers can be about 0.5 to 40 decitex, typically about 1 to 30 decitex. At less than about 0.5 decitex, the fibers can have too low mechanical strength, and at more than about 40 decitex, the number of elastomeric fibers making up the web per unit surface area is reduced; outside of such a range, the fabric can have a reduced recovery from extension. The staple elastomeric fibers can have a length of about 3 to 50 mm, typically about 5 to 30 mm. At a length of less than about 3 mm, the fabric can have low mechanical strength, and at a length greater than about 50 mm, it can be difficult to achieve a uniform distribution of the fibers in the fabric web. No particular limitation

is imposed on the cross-sectional shape of the elastomeric fibers, which can have a round cross-section as shown in Figure 2 or a modified cross-section, for example triangular or flattened.

Useful crimped staple fibers can be polyester fibers, polyolefin fibers, acrylic fibers, and polyamide fibers. Crimp can be developed in such fibers from the corresponding latent crimp fibers by heat treatment under relaxed conditions after the elastomeric fibers, latent crimp fibers, and binder have been mixed, and preferably after a web has been formed therefrom. The latent crimp and corresponding crimped fibers have a bicomponent construction, in which useful polymer pairs include polyethylene terephthalate and poly(ethylene terephthalate-co-isophthalate); poly(ethylene terephthalate) and poly(trimethylene terephthalate); poly(ethylene terephthalate-co-isophthalate) and poly(trimethylene terepthalate); poly(ethylene terephthalate) and poly(tetramethylene terephthalate); poly(hexamethylene adipamide) and poly(hexamethylene-co-2-methyl-1,5-diaminopentamethylene adipamide); and the like.

The latent crimp fibers can have a crimp development temperature which is lower than the softening temperature of the elastomeric fibers. If the crimp development temperature of the latent crimp fibers is higher than the softening temperature of the elastomeric fibers, the ability of the elastomeric fibers to recover from extension can be compromised during crimp development.

The crimped fibers can have a linear density of about 0.2 to 20 decitex per filament, typically about 0.5 to 10 decitex per filament. If the crimped fibers have a linear density of less than about 0.2 decitex per filament, the stretch properties of the fabric can be inadequate. At a linear density of more than about 20 decitex per filament, the fabric can be stiff and have a poor hand. As with the elastomeric fibers, the crimped fibers can have a length of about 3 to 50 mm, typically about 5 to 30 mm. No particular limitation is imposed on the cross-section of the crimped fibers, and they can have a round cross-section as shown in Figure 2, or a triangular, flattened, or a 'snowman' cross-section.

The binder can be a thermoplastic resin such as polyester, polyolefin, acrylic or polyamide. When heated and melted, then cooled and solidified, it bonds the fibers of the web (precursor to the fabric of the invention) together. The melting temperature of the binder can be lower than the softening temperature of the elastomeric fibers so that the ability

of the elastomeric fibers to recover from extension is not compromised when the precursor web is heated to melt the binder. There is no particular limitation on the shape of the binder, and it can be a liquid, a powder, or a fiber as shown in Figure 1 and 2. A fiber shape is preferred, for example having a concentric or eccentric sheath-core construction in which the thermoplastic sheath melts at a lower temperature than the core. Examples of such fibers include those in which the sheath is poly(ethylene terephthalate-co-isophthalate) and the core is poly(ethylene terephthalate). As with the elastomeric fibers, the binder fibers can have a length of about 3 to 50 mm, typically about 5 to 30 mm.

The polymers of which the fibers are comprised can be copolymers, comprising additional monomers that improve their preparation, functionality, or processing, for example for improved dyeability (for example 5-sodium-sulfoisophthalate in polyesters), optimized crimp levels, melt viscosity, adhesion, resistance to environmental degradation, and the like, provided the benefits of the invention are not compromised. Similarly, the fibers can contain additives such as ultraviolet light absorbers, antioxidants, anti-tack agents, lubricants, hindered phenolic stabilizers, hindered amine stabilizers, inorganic pigments such as titanium oxide, zinc oxide, carbon black and the like, antimicrobial agents containing silver, zinc, or compounds thereof, deodorants, fragrances, and anti-static agents such as poly(ethylene oxide), as long as the benefits of the invention are not adversely affected.

In the process of the invention, a suspension of staple elastomeric fibers (preferably spandex), staple latent crimp fibers, and a binder (preferably binder fibers) is prepared. Optionally, a dispersing agent and/or a thickener can be added to the suspension. The suspension is formed into a web by a wet-lay method or an air-lay method, and the web is heated to melt the binder and to crimp the latent crimp fibers. The heating step is preferably carried out with little or no pressure or tension (that is, with the web in a relaxed state) so that the latent crimp fibers are not prevented from crimping, and at a temperature lower than the softening temperature of the elastomeric fibers. The heating step can be carried out in two steps, one for bonding the fibers and one for developing crimp in the latent crimp fibers, or it can be carried out in a single step to accomplish both bonding and crimping.

One embodiment of the process of the invention is described below using the apparatus illustrated schematically in Figure 3. In this particular embodiment, latent crimp fibers and a fibrous binder are used.

First, in a fiber suspension preparation step ("A" in Figure 3), the elastomeric fibers, the latent crimp fibers, and the binder fiber can be added to water and mixed in a rotary device 20 such as a pulper to disaggregate the fibers and make a suspension of fibers in the water so that the suspension has a fiber concentration of about 0.1 to 3 wt%. The suspension can be delivered by pumps ("P") to mixing tank 22 and then to machine tank 24. Optionally, to aid in dispersing the fibers in the suspension preparation step, a dispersing agent, for example a nonionic polyether-based dispersing agent, a weakly cationic polyester/polyether dispersing agent, or the like, can be added for example in an amount of 0.01 to 10% by weight based on the total fiber weight. Optionally, a water-soluble thickener can also be added, for example in an amount of 5 to 50 ppm (thickener solids basis) based on the weight of the water.

Next, in a web-forming step ("B" in Figure 3), the suspension from machine tank 24 can be fed by a pump ("P") to wire conveyor belt 26a of short-screen papermaking machine 26 and dewatered on wire conveyor belt 26a to form a web on the belt. At this step, Figure 4A schematically illustrates one embodiment of the web, which comprises elastomeric fibers 12, latent crimp fibers 14, and binder fibers 16. The web on wire conveyor belt 26a can then be transferred onto felt 28, which can have a smoother surface than wire conveyor belt 26a.

Then, in a bonding step ("C" in Figure 3), the web on felt 28 can be transferred onto cylinder-type dryer 30, which can have a smoother surface than felt 28, and where the web can be heated to a predetermined temperature sufficient to melt sheath 16x of binder fiber 16 within the web. The web can then be pulled away from cylinder-type dryer 30 and cooled to solidify the melted binder so that fibers 12 and 14 are bonded together, for example at points 18 (see Figure 1B), and a nonwoven fabric is formed.

In a crimp development step ("D" in Figure 3), the fabric can be fed by feed rolls 31 to heating oven 32 which can supply heat for example as infrared or far-infrared radiation. The temperature within heating oven 32 can be lower than the softening temperature of elastomeric fibers 12 but high enough to make fibers 14 develop crimp. To allow crimp to develop, it is preferable for the fabric in heated oven 32 to be in a relaxed state.

Accordingly, the peripheral velocities of feed rolls 31 and take-off rolls 34 can be adjusted so as not to apply tension to the fabric. Figure 4B schematically illustrates one embodiment of the fabric at this step, in which the fibers are indicating according to the numbering system used for Figure 4A.

Finally, the fabric can be wound up on winder 36 ("E" in Figure 3).

The foregoing steps and apparatus were used in the Examples, but they illustrate only one embodiment of the invention and can be modified in a number of ways. For example, the tanks which hold the suspension (mixing tank 22 and machine tank 24) may instead consist of one tank, or three or more tanks. In the web-forming step, instead of a short-screen papermaking machines, other types of papermaking machines may be used, such as a Fourdrinier machine or a cylinder machine. In the fiber suspension preparation step and the web-forming step, other liquids such as ethanol may be used as the medium instead of water. Moreover, the length and number of felts which carry the web may be varied, or one or more rolls may be used instead of the felt. In addition, a pressing step in which the web is squeezed under applied pressure may be separately provided between the web-forming step and the bonding step. In the bonding step, other types of heaters (e.g., air dryer, air through-circulation dryer, infrared dryer, suction dryer) may be used instead of a cylinder-type dryer. The bonding step and the crimp development step may be carried out at separate times or places, or these steps may be integrated so as to accomplish bonding and crimp development at the same time.

A step to adjust the hand or surface properties of the nonwoven stretch fabric by passing the fabric between calender rolls (optionally with an embossing surface) (not shown) can be provided between the crimp development step and the wind-up step. In the fiber suspension preparation step and the web-forming step, an air-lay step can be employed instead of a wet-lay step. In an air-lay process, the fibers can be disaggregated and dispersed with an opening machine (not shown) in the fiber suspension preparation step, and a mixed suspension of the fibers can be prepared with a fiber blending machine (not shown). In the web-forming step, a random carding machine can be used to improve the randomness of the fiber orientations.

In the Examples, fabric properties were measured by the following methods. Basis weight and thickness were measured in accordance with Japanese Industrial Standards test number JIS L-1096, and tensile

strength was measured in accordance with JIS P-8113. The recovery from extension was measured by determining the length of a test specimen before testing ($L_o$), subjecting the specimen to five 15% extension-and-recovery cycles on an Instron tester, determining the length of the specimen at the fifth extension ($L_e$), and after the fifth recovery ($L_f$). Percent recovery from extension ($R_e$) was calculated from the following equation:

$$R_e\ (\%) = \quad 100x\ (L_e - L_f)/(L_e - L_o)$$

In Table I, "Comp." means Comparison, and tensile strength is reported in kiloNewtons per meter.

## EXAMPLE 1

The elastomeric fibers used were spandex (Lycra® T-127C, a registered trademark of DuPont-Toray Co., Ltd.) having a linear density of 7 decitex per filament, a fiber length of 6 mm, and a softening temperature of about 180°C. The latent crimp fibers were poly(ethylene terephthalate) + poly(ethylene terephthalate) copolymer bicomponent fibers (T81, made by Unitika Fiber Co., Ltd.) having a linear density of 1.7 decitex per filament, a fiber length of 5 mm, and a crimp development temperature of at least about 140°C. The binder was sheath-core binder fibers of poly(ethylene terephthalate) and poly(ethylene terephthalate-co-isophthalate) (30% isophthalate) ("Melty" 4080, manufactured by Unitika Fiber Co., Ltd.) having a linear density of 1.1 decitex per filament, a fiber length of 3 mm, and a sheath melting temperature of about 110°C.

Five weight percent of the spandex, 65 wt % of the latent crimp polyester fibers, and 30 wt % of the polyester sheath-core binder fibers were dispersed in water using a pulper. Next, 10 ppm (thickener solids, based on the weight of the water) of polyacrylamide thickener ("Myresin" R10L, manufactured by Mitsui-Cytec, Ltd., 40% emulsion) and 1 wt % (based on total fiber weight) of a modified nonionic polyesterether dispersant (MDP-002, made by Takemoto Yushi KK) were added, giving a suspension having a fiber concentration of about 0.5 wt %.

The resulting suspension was wet-laid with a short-screen papermaking machine so that the fibers were substantially randomly oriented, then heated in a cylinder-type dryer having a surface temperature of 120°C to give a web having a basis weight of 22 g/m$^2$. The

web was then passed in a relaxed state through an infrared heater set to 160°C to develop crimp in the latent crimp fiber. Next, the web was pressed with a cylindrical roll at a pressure of 10 kgf/cm, yielding the nonwoven fabric whose properties are shown in Table 1.

**Example 2**

A nonwoven fabric was produced under the same conditions as in Example 1 except that the proportion of spandex was 10 wt % and the proportion of latent crimp polyester fibers was 60 wt %. The properties of the resulting fabric are shown in Table 1.

**Example 3**

A nonwoven fabric was produced under the same conditions as in Example 1except that the proportion of spandex was 20 wt % and the proportion of latent crimp polyester fibers was 50 wt %. The properties of the resulting fabric are shown in Table 1.

**Comparison Example 1**

A nonwoven sfabric was obtained in the same manner as in Example 1 except that no spandex used. The properties of the resulting fabric are shown in Table 1.

**Table 1**

| | Example 1 | Example 2 | Example 3 | Comp. Example 1 |
|---|---|---|---|---|
| Fiber proportions (wt %) | | | | |
| Spandex | 5 | 10 | 20 | 0 |
| Crimped polyester bicomponent fibers | 65 | 60 | 50 | 70 |
| Polyester binder fibers | 30 | 30 | 30 | 30 |
| Fabric properties | | | | |
| Basis weight (g/m2) | 42 | 40 | 38 | 44 |
| Thickness (microns) | 119 | 132 | 124 | 137 |
| Tensile strength, MD (kN/m) | 1.1 | 1.0 | 0.9 | 1.1 |
| Tensile strength, CD (kN/m) | 1.0 | 0.9 | 0.8 | 1.0 |
| Recovery from extension, MD (%) | 69 | 73 | 86 | 50 |
| Recovery from extension, CD (%) | 63 | 67 | 79 | 46 |

The data in Table 1 show that the nonwoven stretch fabrics obtained in Examples 1, 2 and 3 had isotropic recovery from extension which was also very high, compared to the fabric obtained in the Comparison Example 1, which was unsuitable as a stretch fabric. The fabrics of the invention also had good hand (low tackiness) and good flexibility.

## CLAIM(S)

**What is claimed is :**

1. A nonwoven fabric having isotropic recovery from extension of at least about 55% and comprising a binder, about 3 to 50 weight percent bare elastomeric staple fibers based on weight of the fabric, and crimped staple bicomponent fibers.

2. The fabric of claim 1 comprising about 5 to 30 weight percent bare elastomeric fiber, based on weight of the fabric.

3. The fabric of claim 1 wherein the crimped fibers comprise polymer pairs selected from the group consisting of:

poly(ethylene terephthalate) and poly(trimethylene terephthalate), and

poly(ethylene terephthalate) and poly(ethylene terephthalate-co-sophthalate)

having a cross-section selected from the group consisting of side-by-side and eccentric sheath-core, and the binder is a binder fiber present at about 10 to 50 weight percent, based on weight of the fabric and having a melting temperature lower than a softening temperature of the elastomeric fibers.

4. The fabric of claim 1 wherein the elastomeric fibers are spandex and the crimped fibers are present at about 40 to 80 weight percent, based on weight of fabric.

5. The fabric of claim 1 wherein the bare elastomeric fibers are polyurethaneurea spandex and the fabric has a thickness of at least about 50 microns and less than 135 microns.

6. The fabric of claim 1 wherein the elastomeric fibers have a linear density of 0.5 to 40 decitex per filament, the binder is a fiber, and the elastomeric fibers, the crimped fibers, and the binder fibers have a length of 3 to 50 mm.

7. A method of manufacturing the nonwoven fabric of claim 1 comprising the steps of:

(a) providing staple spandex, staple latent crimp fibers which develop crimp when heated, and binder fibers;

(b) preparing a suspension of the spandex, the latent crimp fibers, and the binder fibers;

(c) forming the suspension into a web by a process selected from the group consisting of air-lay and wet-lay;

(d) heating the web to melt the binder fiber and bond the fibers; and

(e) heating the web in a relaxed state to develop crimp in the latent crimp fibers.

8. The method of claim 7 wherein suspension preparation step (b) is carried out so that the latent crimp fibers are present at a level corresponding to 40 to 80 weight percent based on weight of the fabric, and heating steps (d) and (e) are carried out as a single step.

9. The method of claim 7 wherein heating steps (d) and (e) are carried out at temperatures lower than the softening temperature of the spandex.

10. An article comprising the fabric of claim 1 made by the method of claim 7 and selected from the group consisting of apparel interlinings, diapers, substrates for external medications, wiping cloths, and packaging materials.

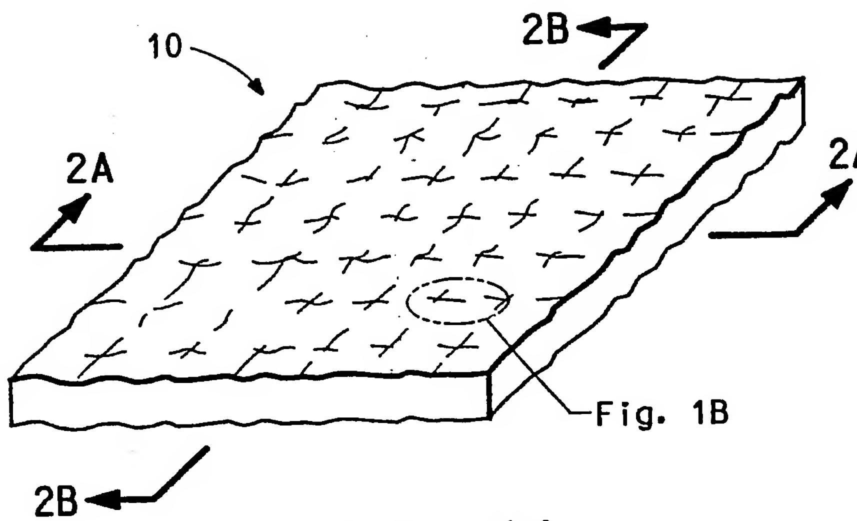



FIG. 1A

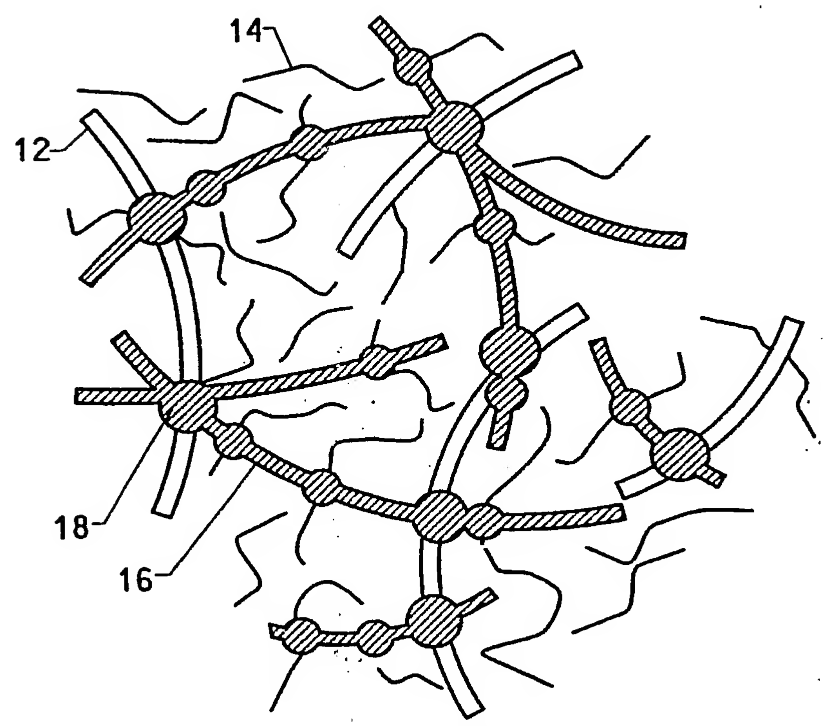



FIG. 1B

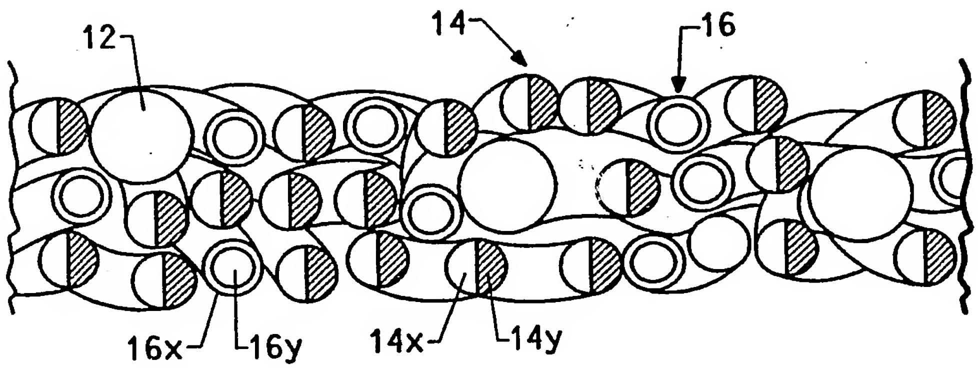



FIG. 2A

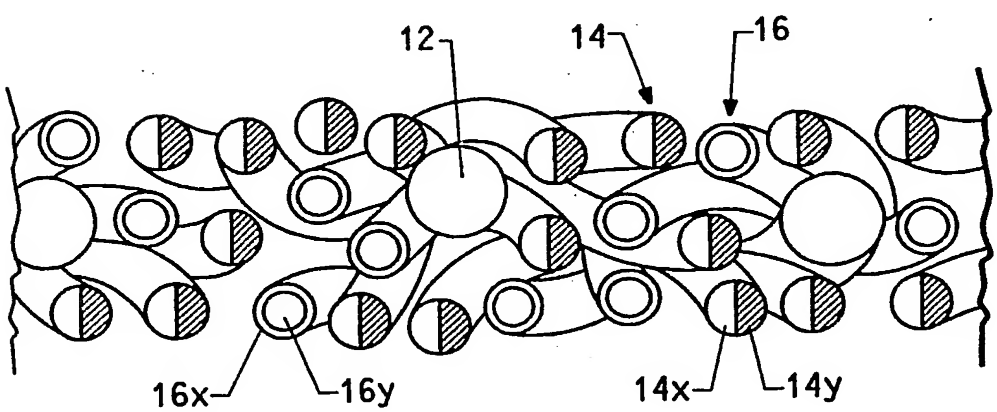



FIG. 2B

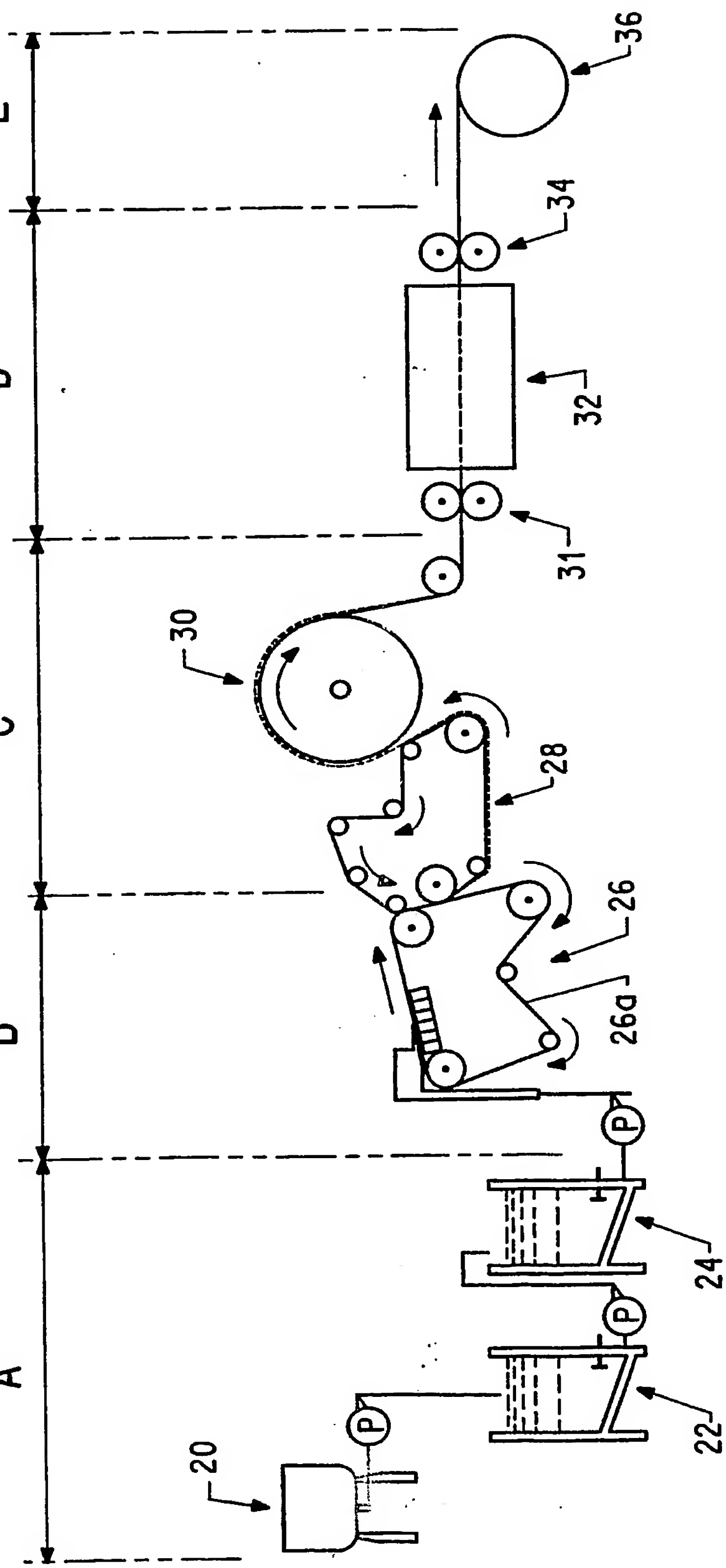



FIG. 3

FIG. 4A

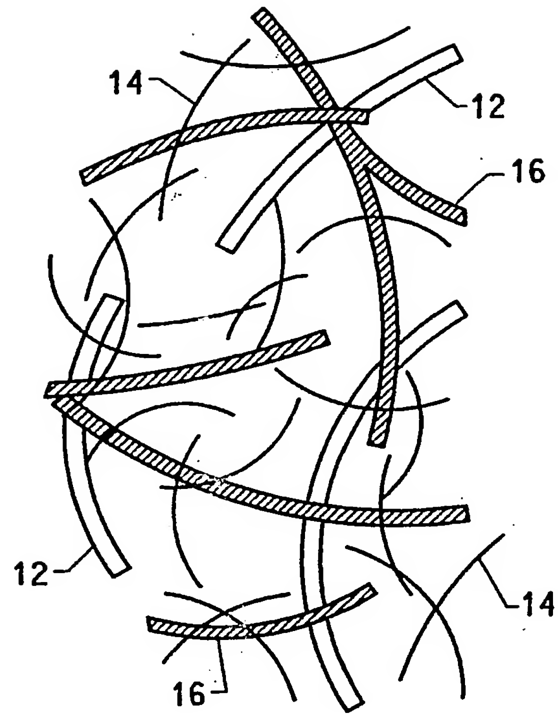
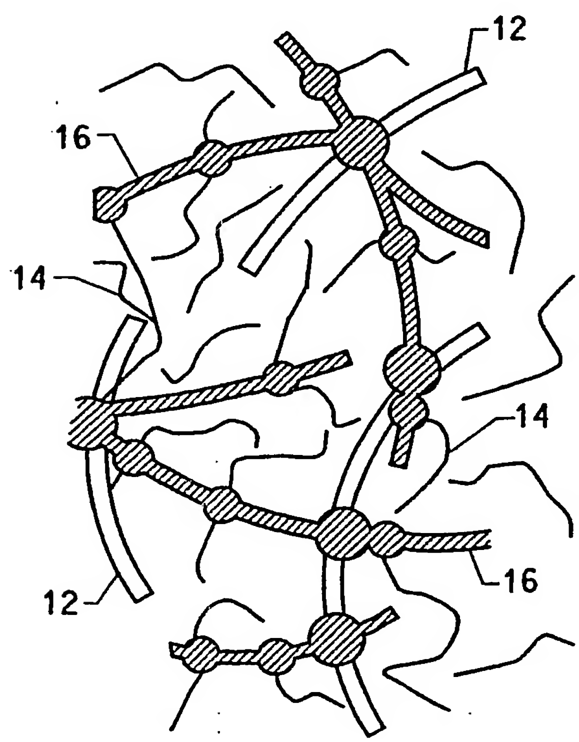



FIG. 4B



# INTERNATIONAL SEARCH REPORT

Int nal Application No
PCT/US 02/35496

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 7 D04H1/06 D04H1/42

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 D04H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Mangin, S |

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